

Structure and Properties of Atoms

PS-2 The student will demonstrate an understanding of the structure and properties of atoms.

PS-2.2 Illustrate the fact that the atoms of elements exist as stable or unstable isotopes.

Taxonomy Level: 2.2-B Understand Conceptual Knowledge

Key Concepts:

atomic number nuclear decay
mass number radiation
isotope
atomic mass

Previous/Future knowledge: In 7th grade, students recognize that matter is composed of tiny “particles called atoms” (7-5.1). Students have no prior learning about isotopes or atoms being stable or unstable.

In Physical Science PS-2.1, students identify and compare the *subatomic* particles that compose atoms and develop a fundamental concept of the role that these three particles have in determining the properties of the atoms that they compose. This indicator (PS-2.2) expands on how the number of neutrons affects the properties of an atom. Students are introduced to the concept of isotopes and to the idea that the nucleus those isotopes can be stable or unstable. The concept of isotopes as stable or unstable is the basis for an understanding of nuclear reactions. Indicators PS-2.6 and PS-2.7 expand on nuclear reactions. Subsequent chemistry courses will further explore nuclear processes and reactions.

It is essential for students to understand

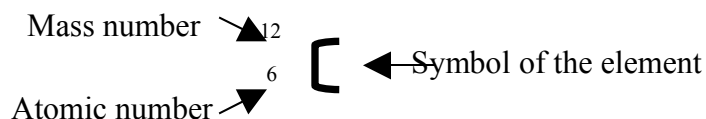
- **Atomic Number:**
 - o The *atomic number* of an element is equal to the number of protons. The atomic number is always the same for a given element.
 - o The atomic number of an element can be found on the periodic table. It is a whole number since it is equal to the number of protons in the nucleus of the atom and is, therefore, the same for all atoms of that element.
- **Mass Number:**
 - o Atoms of the same element may have different numbers of neutrons.
 - o The *mass number* of a particular atom is the sum of that atom’s protons and neutrons.
 - o The mass number cannot be found on the periodic table. (The mass number is not the same as atomic mass and **cannot** be found by rounding off the atomic mass. The mass number must be given through words or a symbol.)
- **Isotopes:**
 - o Atoms of the same element with different numbers of neutrons will have different mass numbers.
 - o *Isotopes* are defined as two or more atoms of the same element having the same number of protons but different numbers of neutrons (and therefore different masses)
- **Atomic Mass:**
 - o The *atomic mass* of an element is the weighted average of the masses of the naturally occurring isotopes of an element.
 - o The atomic mass of an element can be found on the periodic table. Since the atomic mass of an element is an average, it is usually not a whole number.

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Students must be able to

- *Illustrate* isotopes (or recognize illustrations of isotopes) with diagrams, symbols, or with words; in each case, the illustration must indicate that isotopes are atoms with the same number of protons, but different numbers of neutrons.
 - The following are two widely accepted examples of symbols used to illustrate one isotope of carbon:



- It is important that students are familiar enough with the meaning of each of these symbols that they can recognize each, not by position but by logic. (See PS-2.3)
- Understand isotopes with unstable nuclei:
 - In order for a nucleus to be stable, a correct ratio of neutrons and protons should be present in the nucleus.
 - An isotope with an unstable nucleus is radioactive.
 - Due to the unstable condition of the nucleus, radioactive isotopes undergo nuclear decay.
 - *Nuclear decay* is a nuclear reaction that involves emission of energy and/or particles from the nucleus, resulting in a more stable nuclear environment.
 - *Radiation* is the term used to describe the particles and/or energy that are emitted during nuclear decay. (Three types are alpha and beta particles, and gamma rays)
 - Nuclear decay occurs naturally in many elements that are common on earth and there is always some radiation present in every environment.
- Use a periodic table to apply these concepts to describe any atom given enough information. For example, given the symbol of an element, with mass number and atomic number, the student should be able to give the number of each of the basic particles (protons, neutrons, electrons) in the neutral atom of any element. The periodic table (revised August 2007) that students will use on the end-of-course test should be downloaded from the following website (see PS-2.3):

http://ed.sc.gov/agency/offices/assessment/programs/endofcourse/documents/periodtablerevised08_14_07.pdf

Misconception: (Teacher note)

Students often confuse the mass number of a given isotope with the atomic mass of the element. It is important to emphasize that the mass number of a specific isotope of an element must be given to the student in order to calculate the number of neutrons. Students often have the misconception that the mass number of a given isotope of an element can be determined by rounding the atomic mass of the element (found on the periodic table).

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It is not essential for students to

- Memorize the mass number, atomic number or symbol of any element;
- Understand the reasons that some isotopes are unstable;
- Understand the types of nuclear radiation (alpha, beta, or gamma);
- Balance nuclear equations;
- Understand half-life;
- Compare the strong nuclear force and electrostatic force; or
- Determine whether a specific isotope is stable or unstable.

Assessment Guidelines:

The objective of this indicator is to *illustrate* that atoms exist as stable or unstable isotopes; therefore the primary focus of assessment should be to give or use illustrations (descriptions, diagrams, or symbols) of these concepts to show understanding of isotopes. Assessments should test the student's ability to apply this concept to any element, not be restricted to memorized examples. Students should know that some isotopes have nuclei that are "unstable" should have an understanding of nuclear decay as a result of an unstable nucleus, and understand that radiation is a result of nuclear decay.

In addition to *illustrate*, assessments may require students to

- *Interpret* (change from one form of representation to another), for instance, read a written description of an isotope and produce an illustration in the form of a symbol or a diagram;
- *Compare* stable and unstable isotopes;
- *Recognize* isotopes of the same element.